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FOREIGN TECHNOLOGY DIVISION

ELECTRO-INSULATING PRODUCTS MADE OF SILICONE RESINS

By

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ELECTRO-INSULATING PRODUCTS MADE OF SILICONE RESINS

Alicja Zgadzaj

The development of the electrotechnical and electronic industry in the direction of minutiarization, increasing the power and preciseness of function of the equipment,which works sometimes under difficult working conditions, results in more demanding requirements for plastics. Perfect properties of the silicone material in combination with their significant thermal resistence and the resistance against humidity are of interest to the designers. The application of silicons in the field of mechanical engineering is steadily increasing and represents a progress in this field.

Siliconematerials are multimolecular organic compounds constructed from the siliconeatoms. These compounds are connected with the oxygen atoms and, partially, with the carbon atoms. Their properties depend upon the size and structure of molecules, and especially upon the amount and type of organic groups connected with the siliconeatoms. From the standview of specific structure, the silicoorganic materials possess a great deal of properties which are more useful than these possessing proper characteristics of the carbon chain.

They are characterized by:
high resistance to the temperature action within the -50 to + +250°C limits;
insignificant viscosity changes as a function of temperature;
good electro-insulating properties within high range of temperatures and humidity.

The electrical break-down of the organic polymers causes the

carbonization of these polymers and creates a conduction soot layer on their surface. However, when the silicone polymer is disrupted, the SiO_2 layer is being formed; this layer has insulating properties. The silicone materials reveal good chemical resistance, the resistance to oxidation and the physiological neutrality. This group of the silicone polymers' properties has been a decisive factor to use them in a necessary field of application.

The main groups of the silicone production are represented by oils, caoutchouc, lubricants, pastes, electroinsulating resins. At the beginning these products were being produced of the resins imported from capitalist countries. However, in recent years the Institute of Industrial Chemistry has worked out several types of silicone electroinsulating resins designed to be used in the production of the saturated and laminated electro-insulating products.

The production technique of these products has been elaborated in the Gliwice Plastic Materials Enterprise under the European Council for Mutual Assistance with the participation of the Institute of Industrial Chemistry. All the resins were of Polish production.

METHODS OF THE SATURATED PRODUCTS' PRODUCTION

In order to produce saturated products, properly prepared solutions of varnishing silicone resins with a determined admixture of the catalyst. These substances are put on the glass fabrics and shirts by means of the saturation method. The varnishing resin, employed in these products, is produced in such a way that it possesses both good mechanical properties and elastic ones.

This resin's processing is not a complicated matter since it does not require very high temperatures or the repetition of the fabric saturation operation.

The glass fabrics designated to be saturated with the silicone resins have to have a properly prepared surface, i.e. it must be burnt and washed. The type of the fabric, its thickness, its weave and aperture affect significantly the product's properties. A properly selected fabric speed in the drawing machine ensures a proper surface coating and it results in avoiding the surface's possible damages. The amount of the applied catalyst tells on the processing parameters. This amount is strictly determined for a given consignment of the resin. Poland produces the silicone electroinsulating fabrics whose rated thickness amounts to 0.1; 0.15 and 0.2 mm and whose width amounts to 1 m. The fabric is cut into disks of a proper width which brings electroinsulating tapes into being.

A special group of the saturated products is presented by the silicone electroinsulating jackets. These products are made through repeated varnishing and curing of the crude jackets. At present Poland produces the silicone jackets in a meter segments with the 1 to 20 mm diameters.

METHODS OF THE LAMINATED PRODUCTS PRODUCTION

The Polish production of the laminated silicone materials of the electroinsulating constructional type comprises both plates and pipes. These materials are produced by using the silicone resins and carriers, such as glass fabric and asbestos paper. The resin glueing materials' layers affects the mechanical durability, delamination, dielectric properties as well as absorptiveness. Usually, in order to produce this particular group of products the Polish silicone resins of the silak type, characterized as low- and medium pressure resins, are employed. The low pressure

silicone resins is used for the asbestosilicone pipe and plate production and is characterized by higher fluidity and longer gelatination time in comparison with the medium pressure resin applied for the glass-silicone plate production. The plates' prpperties depend not only upon the resin type but also upon the carrier's type and quality. For the production of glass plates, the glass fabrics having special weave and removed aperture are used.

The paper-asbestos-silicone plates are produced through usage of the asbestos paper having small amounts of the basic weight which ensure good saturation. The plate production process comprises both the ironing of a properly prepared semi-finished product in shelf presses under the +175°C temperatue and the seasoning in dryers in order to obtain desirable properties. Only thin plates undergo the seasoning process. The method of the thick plate production comprises only the ironing.

The pipes are made by means of the hot rolling and by retaining a proper pressure of the fabric saturated with a low-pressure silicone resin as well as by the curing process in dryers. The thickness of the produced glass-silicone plates is 0.5 to 30mm, whereas this of the asbestos-silicone ones is 0.5 to 10 mm. The pipe internal diameters amount to 30 to 390 mm and the external diameters are 34 to 400 mm.

PROPERTIES AND APPLICATION OF SILICONE PRODUCTS

The above discussed silicone products possess a great deal of excellent properties which qualify them as the A-class electro-insulating materials. These are the H class insulation materials designated to operate within -50 to +180°C temperature range.

The saturated products

The electroinsulating fabrics, tapes, jackets are the only elastic electroinsulating materials of the H insulation class which are used in the electrical machine industry. Due to their good elasticity, these materials can excellently serve for the winding of different machines' elements and for wires' insulating. These products, when being delivered, have somewhat worse properties because of the intentional undercuring during the production. During the curing process, fabrics, tapes and jackets' elasticity deteriorates, thereby causing undesirable cracking and weakening of the material. Therefore, it is recommended to warm the material when it is in the equipment, e.g. after the coils being wound with the tape. Yet, there is a possibility to start up the equipment's exploitation without warming up, since under surrounding temperatures these materials have sufficient dielectric properties and when the machine is operating, these properties improve quickly Saturated products are characterized by insignificant absorptiveness, by good mechanical and dielectric properties; they are not combustible and are mildew-proof. Some of their properties are summarized in Table I.

Laminated products

This kind of products according to its thermal durability surpasses similar products with an organic adhesive and only to a certain insignificant extent they change their properties during warming. They are characterized by a very good thermal and electric arc resistance. Their chemical resistance is superior to this of silicon varnishing films. The glass-silicone plates have very insignificant water absorptiveness equal to 0.1 to 0.5%.

The asbestos plates because of their carriers' property have somewhat higher water absorptiveness and less useful dielectric properties, retaining, however, better machining and better delamination resistance.

The silicone laminated products are mostly applied for designing the dry-type transformers.

Some properties of the laminated products are summarized in Table II.

In the field of the production of silicone electroinsulating materials Poland is leading ahead of other socialist countries. The glass silicone jackets of the Polish production fit the U.S. ASTM D 372-70 standard as well as the British BS 2848-1973 standard. The comparison of the plate properties according to foreign standards as well as according to the local ones is given in Table III. The Gliwice technical transformers enterprise under the European Council for Mutual Assistance provides the entire country's electrical and electronic industry with the silicone ironed products. The increase of assortment, the optimization of the properties and the cost decrease in the above-mentioned group of products depend upon Poland's raw material base. Particularly it concerns the following:

initiation of the Polish production of proper carriers; mostly glass fabrics which are presently being imported from capitalist countries;

standartization and increase of the assortment of local silicone resins which are presently being produced on the experimental stage in the Sarzyn Motor Experimental Factory.

Table I. The properties of saturated products according to the Polish standards. The material thickness is 0.1; 0.15 and 0.2 mm.

Własność 1	Tkaniny 2 PN-72/E-29000	Koszulki 3 PN-74/E-29000
4 Wytrzymałość na zerwanie w 20°C minimalna, w kG (daN)	20(196)...70(686)	—
5 Rezystywność skrośna minimalna, w Ω.cm	$10^{1[illegible]}$...10^{14}	10^{16}
6 Napięcie przebicia minimalne, w kV	1...1,5	2,3...2,8
7 Napięcie przebicia przy [illegible] minimalne, w kV	1,5.. 2,5	—

Key: (1) Property; (2) Fabrics; (3) Jackets; (4) Rupture resistance under 20°C is minimal,,in kG (daN); (5) Minimum direct-current resistance in Ω cm; (6) Break-down voltage in kV; (7) Break-down voltage under stretching is minimal in kV.

Table II. Properties of laminated products according to the local standards.

Własność 1	Płyty szklano-silikonowe warstwowe wg ZN-MPCh-TS-6754 2	Płyty azbestowo-silikonowe warstwowe wg ZN-75/MPCh-TS-6771 3	Rury szklano-silikonowe warstwowe wg ZN-75/MPCh-TS-6786 4
5 Wytrzymałość na zginanie w 20°C minimalna, w daN/cm²	880	1000	*)
6 Wytrzymałość na rozciąganie, w daN/cm²	880	600	—
7 Odporność na rozwarstwianie, w daN	100	125	—
8 Wytrzymałość na ściskanie, w daN/cm²	—	-	*) (A)
9 Rezystancja elektryczna powierzchni po klimatyzacji, w cm	10^{12}(a + b)**)	10^{10}(a) 10^{9}(b)	10^{12}(a) 10^{10}(b)
10 Rezystywność elektryczna izolacji po klimatyzacji, w Ω·cm	10^{14}(a + b)	10^{9}(a) $5 \cdot 10^{7}$(b)	10^{10}(a) 10^{9}(b)
11 Współczynnik strat dielektrycznych po klimatyzacji — przy 50 Hz — przy 1 kHz — przy 1 MHz	0,06(a + b) 0,08 0,01(I)	0,32(a)	0,05***)(I) 0,05
12 Wytrzymałość dielektryczna warstw w powietrzu, w kV/mm	8	—	—
13 Odporność na próbę napięciową I warstw przy odległości między elektrodami 3 mm po klimatyzacji 4 h/70°C (< 20°C + 15 min 90°C) olej transformatorowy, w kV	—	—	10
14 Odporność na próbę napięciową II warstw po klimatyzacji 4 h/70°C < 20% ww 5 mm na 1 mm grubości (90°C) olej transformatorowy w kV	25	—	10
15 Porównawczy wskaźnik odporności na prądy pełzające po klimatyzacji (a), w V	—	100	
16 Przenikalność elektryczna po (a i b) przy częstotliwościach 50 Hz...1 MHz	55,5	—	—

*) wartość zostanie ustalona po zebraniu materiału statystycznego 17

**) (a) 70°C/4 h;15...35°C/45...75%/6 h
(b) 20°C/93%/24 h

***) I — wartość podana informacyjnie 18

Key: (1) Property, (2) Glass-silicone plates. values according to ZN-MPCh-TS 6754; (3) Asbestos-silicone plates, values according to ZN-75/MPCh-TS-6774; (4) Glass-silicone pipes, values according to ZN-75/MPCh-TS-6786; (5) Bending resistance is minimal under 20°C, in daN/cm^2; (6) Stretching resistance, in daN/cm^2; (7) Delamination resistance in DdaN; (8) Compression resistance in daN/cm^2, (9) Surface's electric resistance after conditioning in cm; (10) Insulation's electric resistance after conditioning in Ω cm; (11) Dielectric loss coefficient after conditioning under 50 Hz, under 1 kHz, under 1 MHz; (12) Resistance of dielectric layers in the air in kV/mm; (13) Resistance to the voltage input I layers when the distance between the electrodes is 3 mm after conditioning 4h/70°C (<20°C + 15 min 90°C), transformer oil, in kV; (14) Resistance to voltage input II layers after conditioning 4h/70°C < 20% of the above-mentioned, 5 mm per 1 mm of thickness (90°C), transformer oil, in kV; (15) Comparative coefficient of the resistance to the currents screeping after the (a) conditioning in V, (16) Electric permeability after the (a + b) under the 50 Hz to 1 MHz frequencies, (17) The value will be submitted after the collection of statistical material; (18) the value is submitted informatively.

Table III. Comparison of the properties of glass-silicone plates and the asbestos ones according to the GOST, DIN, TGL, ZN standards.

1 Własność	2 Płyty szklano-silikonowe wg norm.			3 Płyty azbestowe wg norm.	
	GOST-12652-67	DIN 7735	ZN-71	TGL-13689	ZN-71
4 Wytrzymałość na zginanie*), w N/mm^2	—	125	80	100	100
5 Wytrzymałość na zrywanie, w N/mm^2	88	90	—	80	60
6 Wytrzymałość na rozwarstwianie, w N	800	1000	1000	1250	1950
7 Wytrzymałość na ściskanie*), w N/mm^2	—	50	—	80	—
8 Udarność w kierunku prostopadłym w KJ/m^2	—	40	40	15	15
9 Palność (skala 0—5)	—	3	3	—	niepalny wg PRS
10 Rezystywność powierzchniowa po (a+b)**), w Ω.cm	—	10^{16}	10^{10}	10^{9}	5.10^{6}
11 Rezystywność w stanie wyjściowym po (a+b)**), w Ω.cm	10^{14} 10^{10}	— —	— —	— —	— —
12 Rezystancja izolacji w stanie wyjściowym (a+b)**), w Ω	10^{14} —	— 10^{10}	— 10^{10}	5.10^{9} —	— $5.10^{?}$
13 Współczynnik strat dielektrycznych po (a+b) przy 50 Hz**) w 20°C	—	0,05	0,06	—	—
180°C	0,2	—	—	—	—
przy 50 Hz po (a) w 20°C	—	—	—	0,27	0,32
14 Odporność na próbę napięciową II warstw po (a+c), w kV	—	25	25	—	—

Norma DIN nie obejmuje płyt azbestowo-silikonowych. 15

(a)
(b) jak w tablicy II 16

(c) 90°C olej transformatorowy 17

*) ze względu na różnice w wymiarach kształtek wyniki mogą się różnić o około 5% 18

**) wyniki nieporównywalne ze względu na odmienne warunki klimatyczne. 19

Key: Property, (2) Glass-silicone plates according to the standards; (3) Asbestos plates according to the standards; (4) Bending resistance* in N/mm^2; (5) Rupture resistance in N/mm^2; (6) Delamination resistance in N; (7) Compression resistance* in N/mm^2; (8) Impact in the perpendicular direction in KJ/m^2; (9) Combustibility (0-5 scale); (10) Surface resistance after the (a + b)** in Ω cm; (11) Resistance under initial position (a + b)** in Ω cm; (12) Insulation resistance under initial position (a +b)** in Ω; (13) Coefficient of dielectric loss after (a + b) under 50 Hz** at 20°C, 180°C under 50 Hz after (a) at 20°C; (14) Resistance to the voltage input of II layers after (a + c) in kV; (15) the DIN

standard does not comprise the asbestos-silicone plates; (16) similar to Table II; (17) 90°C transformer oil; (18) due to the difference in forms dimensions the results can vary to about 5%; (19) Results are not comparable because of different climatic conditions.

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